I. Project Title: Upper Yampa River Northern Pike Tagging

Note: Synthesis report of 2004, 2005, and 2006 due in March 2007.

II. Principal Investigators:

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III. Project Summary

The Recovery Program has established an active program to control nonnative fishes in the main rivers of the upper basin to assist in recovery of the endangered fishes found there. In some cases, such as the Yampa River, northern pike have been removed from the main channel and stocked into off-channel impoundments to provide fishing opportunity for local anglers. Concern has been expressed by sportfish managers for adequate evidence to justify the need to remove northern pike outside of critical habitat for endangered fish. The large population of northern pike in the upper Yampa River is suspected of being a source for continual movement of northern pike into the lower Yampa River and further downstream into the Green River where they coexist with three endangered fishes — Colorado pikeminnow *Ptychocheilus lucius*, razorback sucker *Xyrauchen texanus*, and humpback chub *Gila cypha*. However, the rate of dispersal is unknown. Information on the rate of emigration of northern pike from upstream reaches is important in determining whether ongoing removal efforts for northern pike in downstream, critical habitat reaches are being negated by recolonization from upstream populations. This evidence is important to determine whether northern pike removal in the upper Yampa River is warranted.

Objectives of this study are to determine population size and structure of northern pike in the study reach and to determine movement into critical habitat in this, and future years.

IV. Study Schedule: To be continued as needed

V. Relationship to RIPRAP:
GREEN RIVER ACTION PLAN: YAMPA AND LITTLE SNAKE RIVERS
III.A.1.b Control northern pike.
III.A.1.b(2) Reduce northern pike reproduction in the Yampa River.

VI. Accomplishments of FY 2004 Tasks and Deliverables, Discussion of Initial Findings and Shortcomings:

Study Site

The Yampa is a free flowing river that originates on the west slope of the Rocky Mountains and flows 320 km to its confluence with the Green River. The portion of the Yampa that makes up the study site flows through low gradient agricultural lands and through the community of Steamboat Springs, Colorado. Seasonal flows in the study reach fluctuate between 100 and 6,800 cubic feet per second (USGS, provisional data) however in recent years there has been a drought and flows have typically been lower. All sampling for this study was conducted within a 35-mile reach of the Yampa River near Steamboat Springs, CO (Figure 1).

Materials and Methods

Northern Pike were collected using three electrofishing passes through a 28.3-mile reach of the Yampa River. In addition to the three passes through the main study area, one pass was made through a disconnected 5-mile reach of the Yampa River above the main study site and a pond that contains pike but does not connect to the Yampa annually was sampled. Northern Pike were the only fish targeted in this study.

All northern pike captured were tagged and released. Pike were tagged using a T-bar tag with an individual tag number and a passive integrated transponder (PIT) tag. Lengths and weights of northern pike, discharge, electrofishing time, release location, and capture reach were recorded.

Movement Determination

The 28.3 mile study reach for the 2004 sampling effort was broken into sub reaches that are approximately two miles in length. Land ownership and logistics made exact 2-mile reaches impossible. Movement was analyzed by comparing the release location (bottom of the reach the fish is captured and released in) and recapture location. Recapture location was estimated by assuming that when pike were recaptured they were caught in the middle of that reach. For example, if a fish was caught in between river miles 140.9 and 138.9, we know it was released at 138.9, as that is the downstream part of the reach where fish were worked and

released. If that fish was then recaptured in reach 146.9 to 144.9 we do not know exactly where the fish was recaptured in the reach. However, if we assume it was recaptured in the middle of the reach then we determine its recapture location was 145.9. The assumption of equal distribution of favorable habitat by reach was made. Considering the large sample size of northern pike recaptured and analyzed for movement in this study the Central Limit Theorem would dictate this technique valid.

Movement was analyzed using fish captured between years, utilizing tags recaptured from other investigators (Table 1), and within this years sampling. Movement is difficult to determine in a single year. Fish tagged and released in a lotic ecosystem may exhibit a "fallback response" to being marked, where they are tagged and drift downstream (Moser and Ross 1993, Hughes 1998). When analyzing within year movement, all fish that moved downstream 2 miles or less were eliminated from analysis. We did this to avoid biasing estimates towards downstream movement. We feel that since fish are released at the bottom of a reach, we may have collected fish on the next pass a short distance downstream and erroneously concluded it had moved further without this elimination.

Population Estimation Techniques

The northern pike adult population was estimated using standard multiple mark recapture methods and program CAPTURE (White et al. 1992) closed population models as well as POPAN models in program MARK. A population estimate was made for only 28.3 miles of the 35-mile reach since this was the only portion of the study reach sampled with the standard 3-pass methodology. Pike numbers were loosely extrapolated out to the entire 35-mile reach.

We eliminated 38 of the smallest fish (< 340mm) from population estimate analysis data set as they were very small, and unlikely to be recaptured. Of the 38 small fish caught, only one was recaptured (2%) as opposed to 40% of the adult fish tagged that were recaptured at least once.

Movement into and out of the study reach over the 4-week sampling period is an issue in meeting closure assumptions. Considering the small length of time covered by the study and the fact that bigger fish were targeted, recruitment into the population and mortality are not issues in determining population closure.

Results and Discussion

Overview

Four hundred and forty two northern pike (175 male, 46 female, and 221 undetermined) were collected in the main study area, 44 in the reach below Catamount (16 male, 8 female, 20 undetermined), and 24 in the off-channel pond (11 male, 1 female, 12 undetermined). Length-weight relationship is shown in Figure 2.

Population Size and Structure

The adult population estimation of northern pike in a 28.3 mile reach of the upper Yampa River for 2004 is 441 (423 to 473 95% C. I.) based on the M_b model in program CAPTURE (Table 2). Given the population was only estimated for one portion of the Yampa, we estimated there were 16.00 northern pike per mile in the Yampa study reach and extrapolated this to upstream sections that were not 3-pass sampled. This yields an estimate of 106 pike in theYampa above the main study reach, for a total of 546 pike in the 35-mile section from the Highway 40 Bridge to The Catamount Reservoir Dam. The above-mentioned extrapolation is not as precise and accurate as a mark recapture population estimate but rather a guideline as to abundance of fish in the entire reach.

A population estimate of 441 pike appears to be a low number of fish in the reach sampled because we captured 398 unique fish. Program CAPTURE selected the behavior model and calculated a probability of first capture of 0.537. It is unlikely that we would be able to capture pike with that efficiency. When compared to pike capture efficiencies in lower stretches of the Yampa River (see Finney and Haines, 2004), capture efficiencies in this stretch of river are high. One possibility is our ability to sample a larger area or proportion of the river with each pass in the narrower upper river.

To address our perceived low estimate we ran simulations in program CAPTURE. The results of a simulation run where the “true” population was assumed to be 800 fish with time varying probabilities of capture (model M_t) for each pass of 0.29, 0.23, and 0.17 showed that about half the time model M_b was erroneously selected and produced estimates averaging 542 fish or a relative bias 32% too low. From the range of estimates in Table 2, we suspect the northern pike population in the 28.3 mile main reach falls between 450 and 1000 fish.

We ran the same data set as used in program CAPTURE in program MARK using POPAN models (a robust parameterization of Jolly-Seber models). From the set of models implemented into program MARK the best-supported model derived the population estimate (N) parameter at 616 (560-691) with a p-hat of 0.43. We believe this is the more accurate estimate.

Length frequencies for pike are outlined in Figure 3, overall and by reach. Length frequency in the main reach is broken out into three sections. These three sections are from river mile 198.8 – 194.1, 194.1 – 183.3, and 183.3 – 170.8. The top, or upstream, reach is above Steamboat Springs where the river channel has more natural hydrography with numerous side channels and backwaters. The middle reach, through Steamboat Springs and below has been channelized and altered for development and recreation. The lower section is also relatively unaltered but has the input of the Elk River, a large tributary to the Yampa. The mean lengths for the upper, middle, and lower main reaches are 524.32mm, 641.89mm, and 671.93mm, respectively, and are significantly different (d.f = 382, F = 30.705, P <0.001). The upper reach contains smaller fish and is a probable spawning ground and nursery area due to meandering channel topography and the associated slow water vegetated habitats.

Capture per effort, divided by portion of the main reach sampled, indicates a higher proportion of the pike population reside in the upper reach, fewer in the lower reach, and fewest in the middle, heavily channelized reach (Table 3).

Movement

Movements were detected from one hundred and fifty one fish captured during this years tagging effort and twenty-two fish captured from studies in previous years (Table 4). Northern pike movement ranged from 5.5 miles upstream to 48.2 miles downstream (Figure 4). The mean movement of pike, no matter how analyzed, was downstream (Table 4). Forty seven fish moved downstream and out of the study reach. One of the 47 pike that moved out of our study reach was collected in critical habitat having moved downstream 93.6 miles in 31 days.

Removal Potential

The potential for removal of a large number of pike in this reach is high. This is due to the high probability of capture in the reach associated with a narrow channel and subsequent increase in sample efficiency. If removal were to be implemented, the population could be reduced to less than 50 individuals in six passes (Figure 5). This estimate is derived from our estimates of N and p-hat and does include immigration, emigration, or recruitment.

Catamount Reservoir Escapement

Eleven northern pike were captured in our sampling that had escaped from Catamount Reservoir. Seven of the fish were recaptured in the 5-mile reach sampled one time directly below the dam. The four other pike were recaptured in the main portion of the study reach from approximately 7.7 to 25.6 miles from Catamount Dam.

The population estimate of adult northern pike (> 350mm) for Catamount Reservoir is 1683 (95% C. I. 1520 – 1894) (B. Atkinson, personal communication). Approximately 40% of the adult northern pike in Catamount Reservoir were tagged. Extrapolating out our 11 adult pike captured, and considering the 40% tagging rate, suggests that about 30 adult northern pike have escaped from Catamount and are now residing in the Yampa River. This number is an underestimate considering that we were not able to sample all of the Yampa River below Catamount, where a concentration of these fish seems to be, and some of the portions that we were able to sample, we were not able to sample thoroughly.

VII. Recommendations:

1. Continue to follow movement of fish marked in previous years

VIII. Acknowledgements:

The authors wish to thank numerous seasonal personnel for their help in the field. We would also like to thank Tim Modde and Bruce Haines for providing valuable comments to an earlier draft and Bruce Haines for help in data analysis.

IX. Project Status:

The project is considered on track but minor revisions are suggested. It is subject to review prior to continuation.

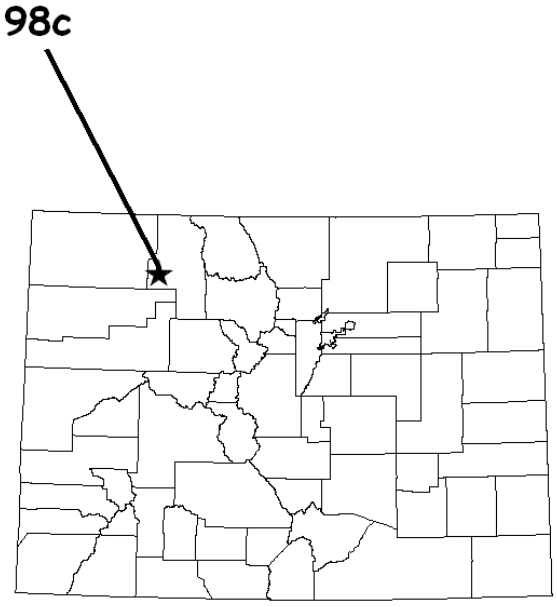
X. FY 04 Budget Status:

A. Funds provided: $44,260
B. Funds expended: $44,260
C. Difference: -0-
D. Percent of the FY 2004 work completed: 100
E. Recovery Program funds spent for publication charges: -0-

XI. Status of Data Submission:

Data will be sent to the database manager in 2004. Data are currently being entered in Microsoft™ Excel spreadsheets.

XII. Signed: Sam Finney and Bill Atkinson — November 8, 2004
Principal Investigators — Date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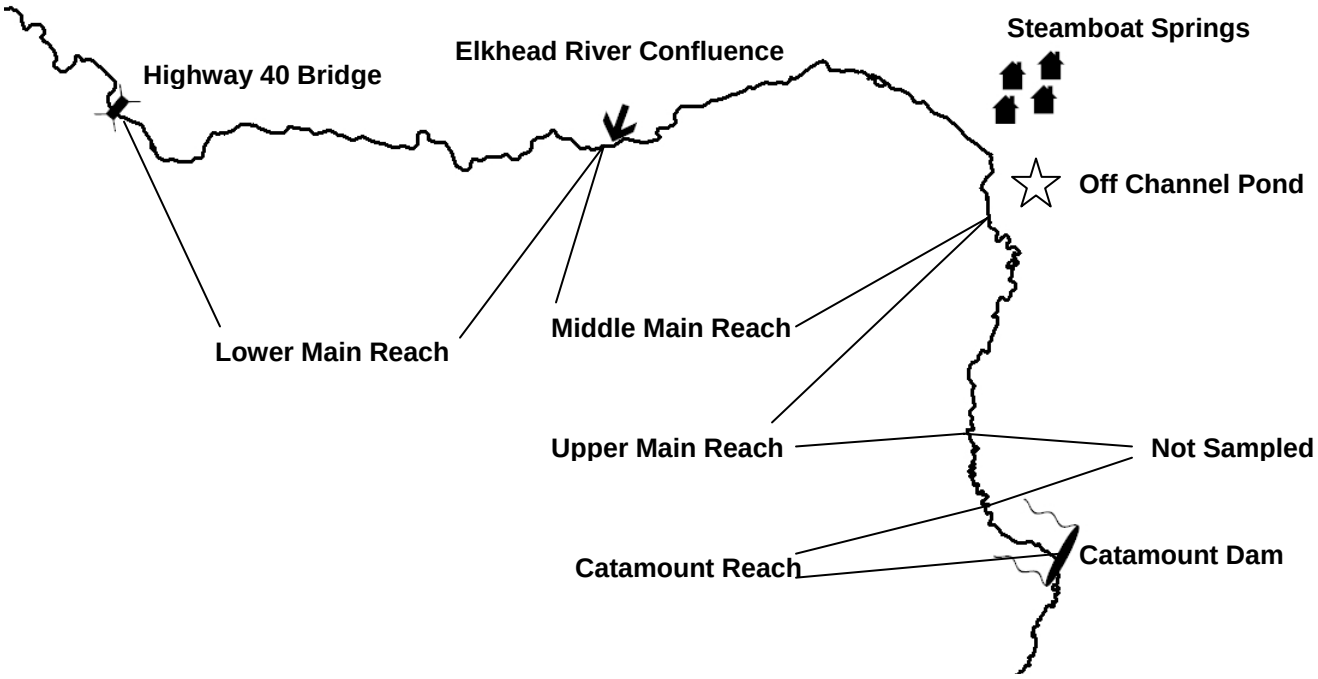


Figure 1.—Map of the study area of 98c.

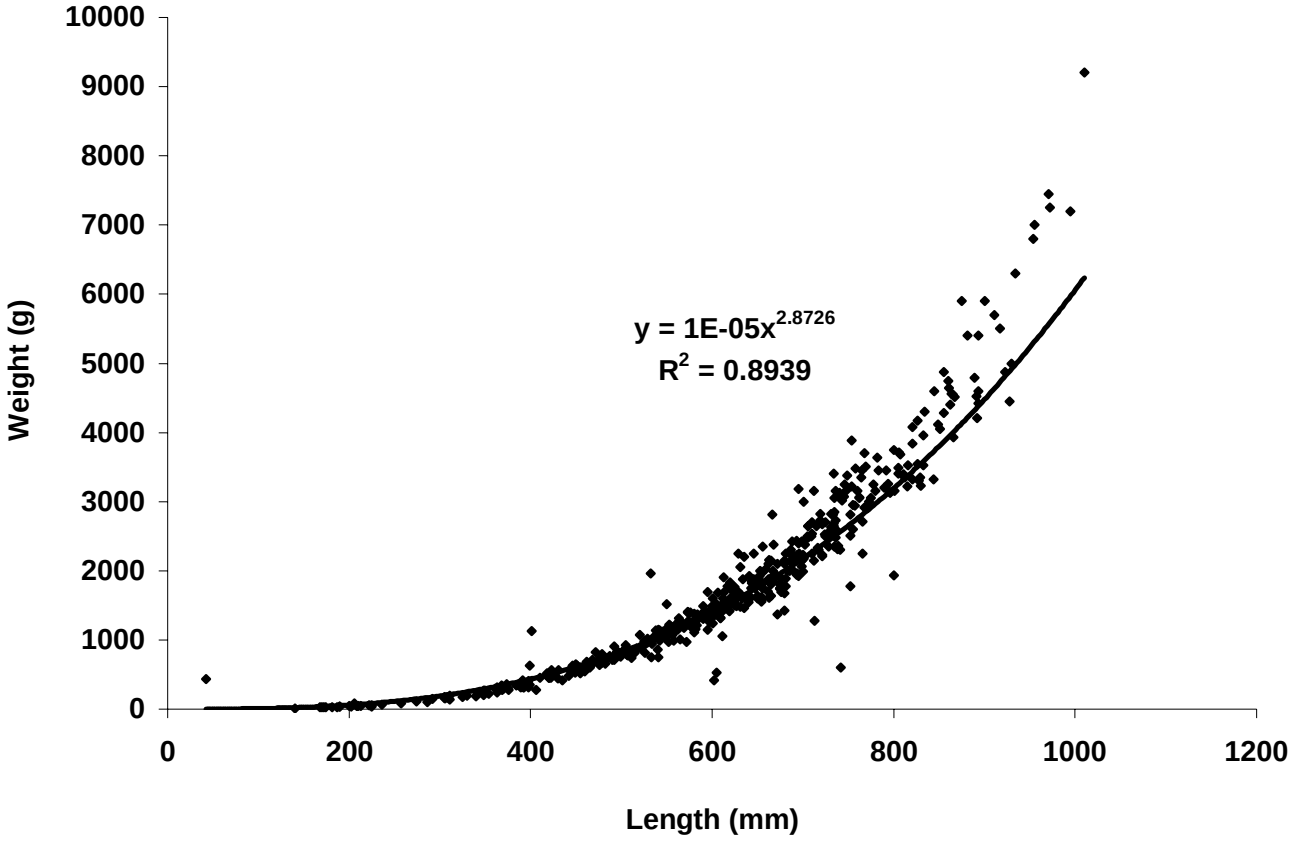
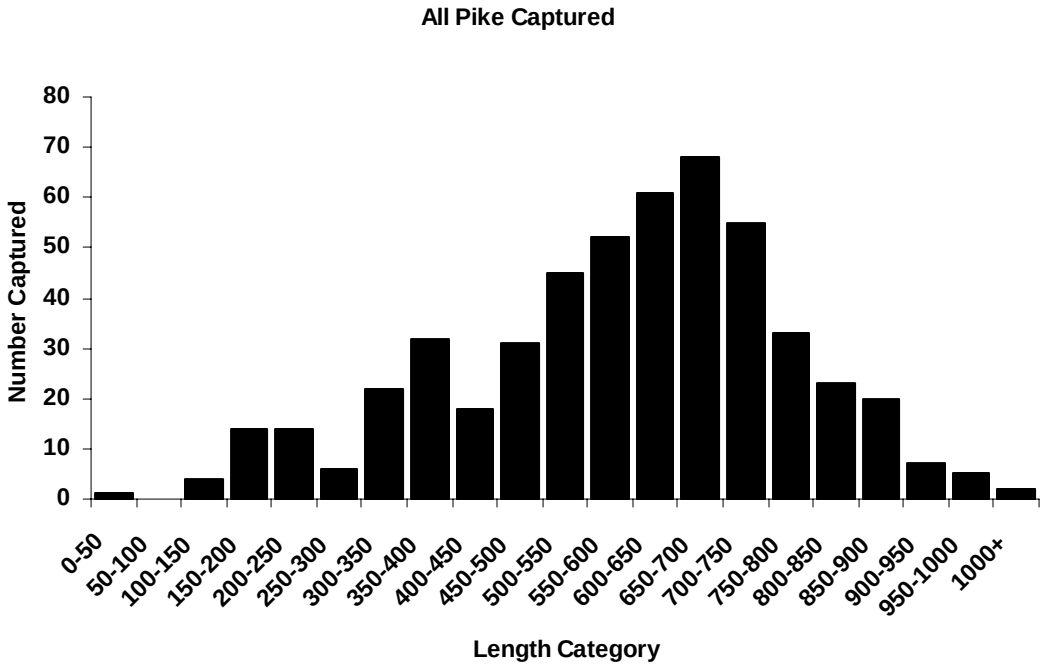


Figure 2.—Length-weight relationship of northern pike captured in the upper Yampa River, 2004.


All Pike Captured
Number Captured
0
10
20
30
40
50
60
70
80
0-50
50-100
100-150
150-200
200-250
250-300
300-350
350-400
400-450
450-500
500-550
550-600
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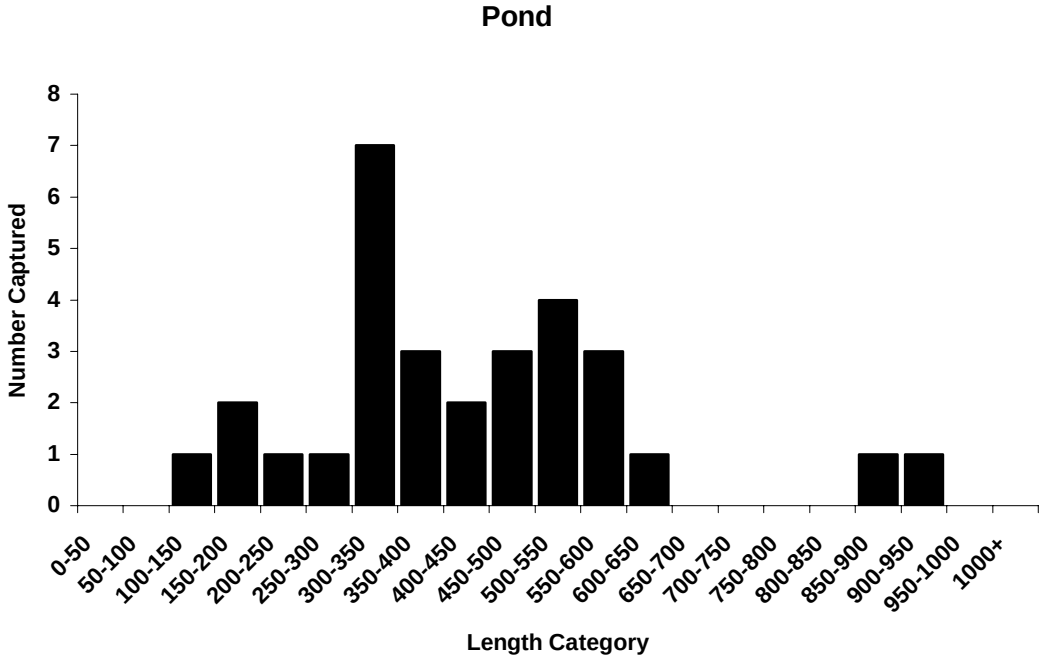
650-700
700-750
750-800
800-850
850-900
900-950
950-1000
1000+
Length Category

(a)


Pond
Number Captured
0
1
2
3
4
5
6
7
8
0-50
50-100
100-150
150-200
200-250
250-300
300-350
350-400
400-450
450-500
500-550
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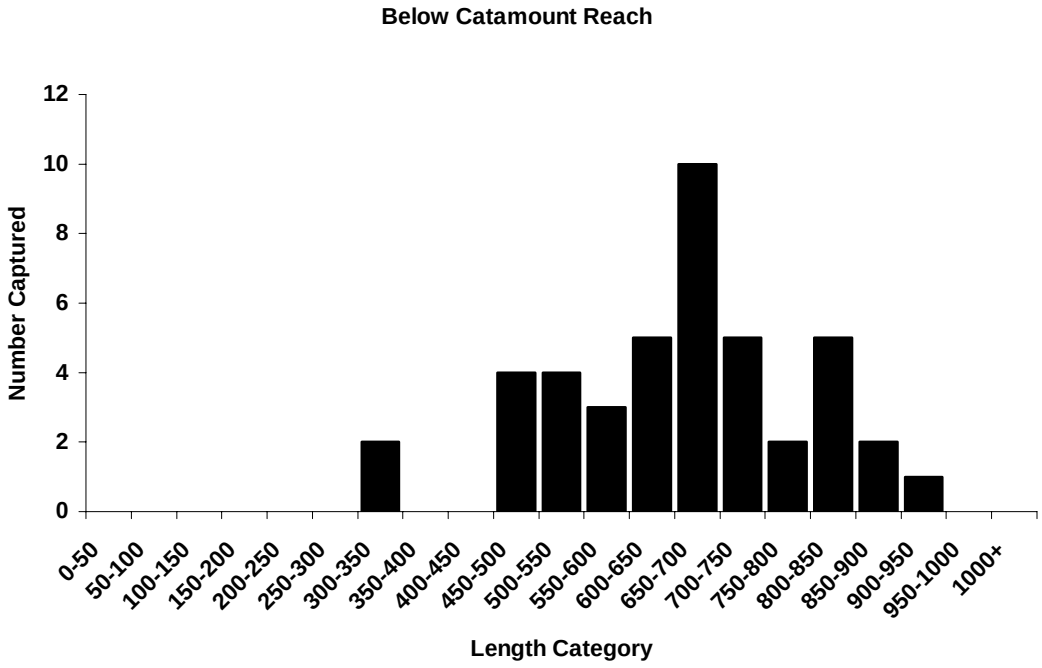
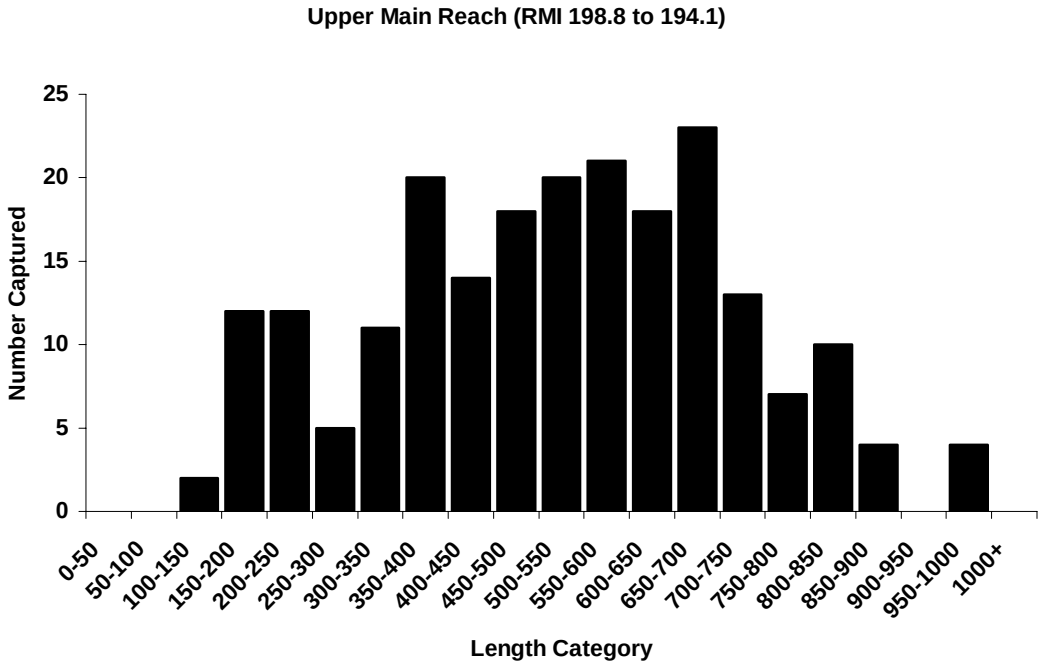
850-900
900-950
950-1000
1000+
Length Category

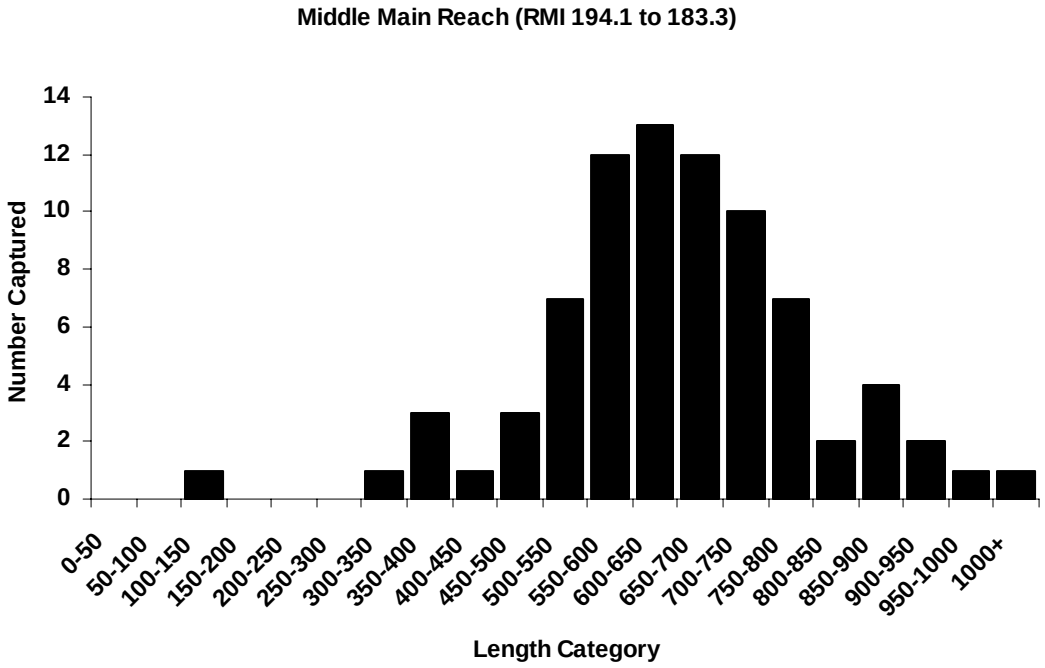
(b)


Below Catamount Reach
Number Captured
0
2
4
6
8
10
12
0-50
50-100
100-150
150-200
200-250
250-300
300-350
350-400
400-450
450-500
500-550
550-600
600-650
650-700
700-750
750-800
800-850
850-900
900-950
950-1000
1000+
Length Category

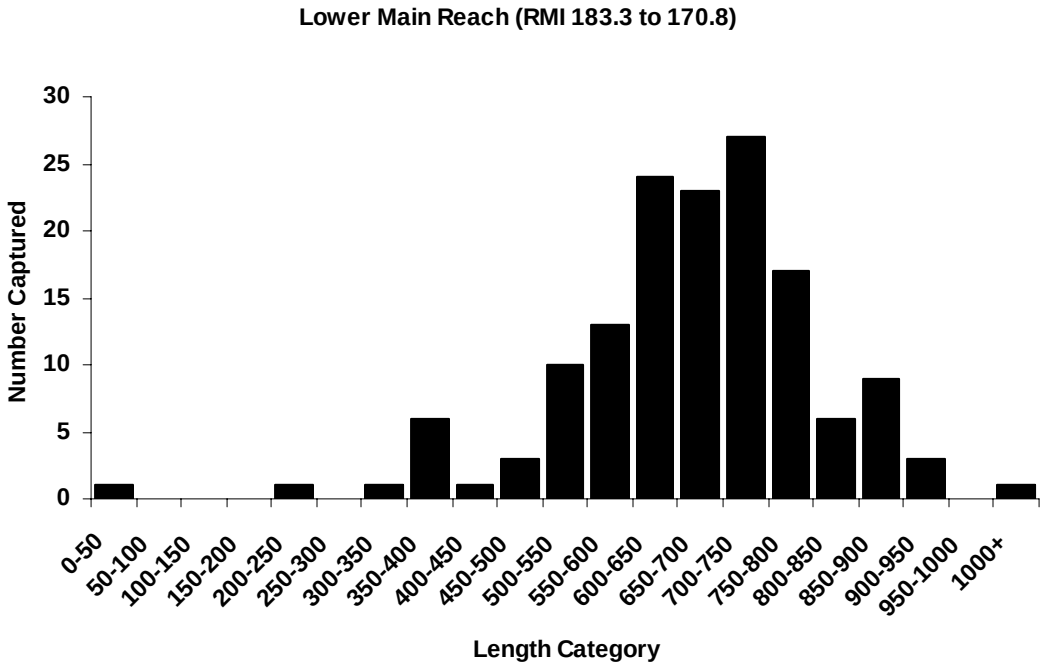
(c)


Upper Main Reach (RMI 198.8 to 194.1)
Number Captured
0
5
10
15
20
25
0-50
50-100
100-150
150-200
200-250
250-300
300-350
350-400
400-450
450-500
500-550
550-600
600-650
650-700
700-750
750-800
800-850
850-900
900-950
950-1000
1000+
Length Category

(d)



(e)



(f)

Figure 3.—Length histograms of all northern pike captured (a), pike captured in the off channel pond (b), pike captured in the single pass below Catamount Reservoir (c), and all pike capture in all three passes in the upper (d), middle (e), and lower (f) portions of the main reach of the upper Yampa River, Spring, 2004.

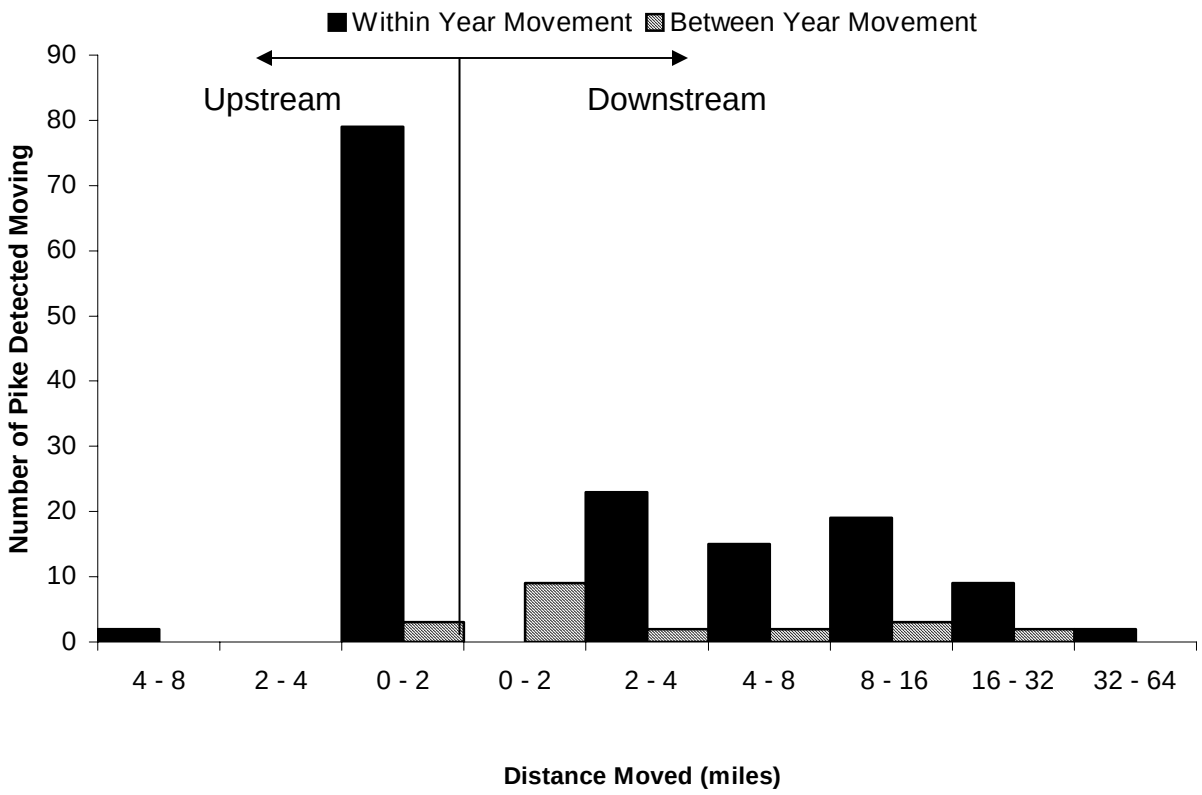


Figure 4.—Graph showing distance and number of northern pike that moved upstream or downstream within (dark bars) or between years (striped bars). Pike moving downstream less than 2 miles are excluded.

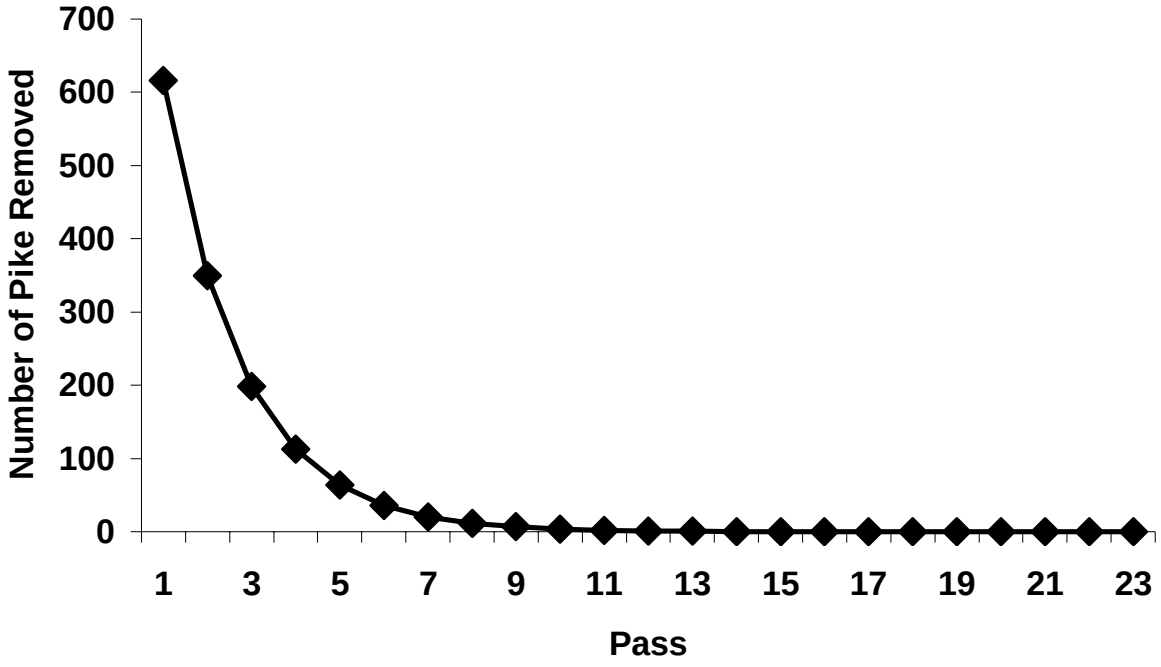


Figure 5.—Theoretical removal time frame for northern pike in the upper Yampa River, Colorado.

Table 1.— Summary of tags from previous studies analyzed for movement.

Investigator(s)	Number of Tags	Analyzed Study Objective	Tag Color
U.S. Fish and Wildlife Service	2	Movement	Red
C.S.U./ C.D.O.W.	8	Backwater Escapement	Yellow
C.D.O.W.	12	Catamount Pop. Est.	Orange

Table 2.—Population estimates for northern in the upper Yampa River, 2004. Program CAPTURE selected the time M (b) model as the most likely estimate.

Model	N (95% C.I.)	Standard Error	p-hat	Model Selection Criteria[a]
M (o)	588 (538 to 650)	28.5237	0.3137	0.22
M (h)[b]	650 (610 to 699)	22.9341	0.2836	0.11
M (b)	441 (423 to 473)	12.4226	0.537222	1.00
M (bh)	441 (422 to 471)	12.4226	0.537	0.54
M (t)	574 (529 to 635)	26.9941	0.3200[c]	0.00
M (th)	890[d] (695 to 1213)	129.1560	0.2066[c]	0.32
M(tb)	472 (418 to 681)	57.318	0.458[c]	0.70
M(tbh)	NO ESTIMATOR			0.34

[a]Model selected has the highest value, [b]Interpolated, [c]Mean p-hat for all 3 passes [d]Bias-corrected estimate

Table 3.—Catch per unit effort for the three subsections of the main reach sampled

	Upper Reach	Middle Reach	Lower Reach
Pike caught per hour of electrofishing	13.931	3.375	6.086

Table 4.— Summary of northern pike movement in the Upper Yampa River, 2004. Data are divided by the four analysis categories. The range of movement for ALL pike tagged was 48.2 miles downstream to 5.5 miles upstream.

	# that moved downstream	# that moved upstream	Mean movement[a]
This Years Fish (Except fish moving downstream < 2 Miles)	68	93	3.66 miles DS
Previously Tagged Fish	18	4	4.74 miles DS

[a] DS = downstream

Literature Cited

Hughes, N. F. 1998. Reduction in growth and tagging may change interannual movement behavior of stream salmonids: evidence from arctic grayling in an interior Alaskan stream. Transactions of the American Fisheries Society 126:1072-1077.

Moser, M. L., and S. W. Ross. 1993. Distribution and movements of anadromous fishes of the lower Cape Fear River, North Carolina. Final Report to U.S. Army Corps of Engineers, Wilmington, North Carolina.

White, G. C., D. A. Anderson, K. P. Burnham, and D. L. Otis. 1982. Capture-recapture and removal methods for sampling closed populations. Los Alamos National Laboratory, LA-8787-NERP, Los Alamos, New Mexico.